national accelerator laboratory

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MUON BEAM HALO STUDIES

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Routine monitoring of the muon beam line led to the discovery of two associated but unplanned beams. These beams were then more thoroughly investigated to ascertain that the Neutrino Department was not exceeding R. R. Wilson's dose limit of 10 mrem/yr at the site boundary, and to determine if there would be more problems at higher intensity.

The data was collected using 2 types of measuring devices. For the very low levels, such as at the site boundary, a mobile environment monitoring station (MERL) was used. This monitoring station is equipped with two 8" x 8" scintillation counters with the associated fast electronics. The monitoring station was also used behind the Muon Lab and Lab A. For monitoring at high exposure levels a hand-held tissue equivalent ionization chamber was used (HPI). The beam was stable and tuned for 150 GeV/c muons; all readings were normalized to the NØ SEM just upstream of the muon target.

The two additional muon beams which were found are discussed below. Their peak positions when the cyclotron magnet is on were 63.9 ft. and 43.9 ft. west of the NØ beamline at a point behind the Muon Lab. Figure 1 depicts these peaks at the three positions where the MERL was used. Figures 2a and 2b show the beams as measured at the Muon Lab. Figure 3 depicts the beams' relative intensities. The lines in Figures 1 and 2 are drawn to guide the eye along the path of the muons. The extrapolated path of the westernmost beam misses the cyclotron magnet; hence, the extrapolation can be extended upstream of the Muon Lab. One then concludes that at least part of this beam is coming from

Enclosure 101. There are three additional pieces of information which lend credence to this belief. First, turning off the eastward bending magnet in Enclosure 101 (1E1) more than doubles the beam intensity. Second, this beam falls much faster in intensity in going from the Muon Lab to Lab A than does the eastern beam; this is the behavior expected for a beam going through the length of berm necessary to get out of E-101. Finally, the width (FWHM) of the western beam is roughly an order of magnitude larger than that of the eastern beam.

Data taken with the HPI survey meter shows (fig.2a) that the beam coming from E-104 is partially intercepted by the western yoke of the cyclotron magnet. The portion which does not go through the yoke forms the eastern beam shown in figures 1 and 2. The portion that does pass through the yoke is bent to the west, and merges with the muons coming from E-101. (fig.2)

One explanation for these effects is the finite momentum bite of the beam line and the fact that muons (unlike hadrons) are not stopped by the iron of the magnets. Hence, poorly focused muons enter low field region or return legs of magnets and consequently do not follow the main beam line. More beam time is required to determine whether the cause of the site boundary problem is due to off momentum or poorly focused beam in Enclosure 104.

The dose rate at the site boundary should be proportional to the targeted beam current as monitored by the NØ SEM. Under the operating conditions studied, the Director's limit of 10 mrem/yr at the site boundary will be reached when 4×10^{12}

p/pulse are incident on the muon target continuously for 365 days/yr. A reduction in operating time would allow a corresponding increase in the average proton beam intensity on target. As an extreme case, at the design intensity of 5×10^{13} the Muon Lab would only be able to operate 30 days/yr, unless some corrective action is taken.

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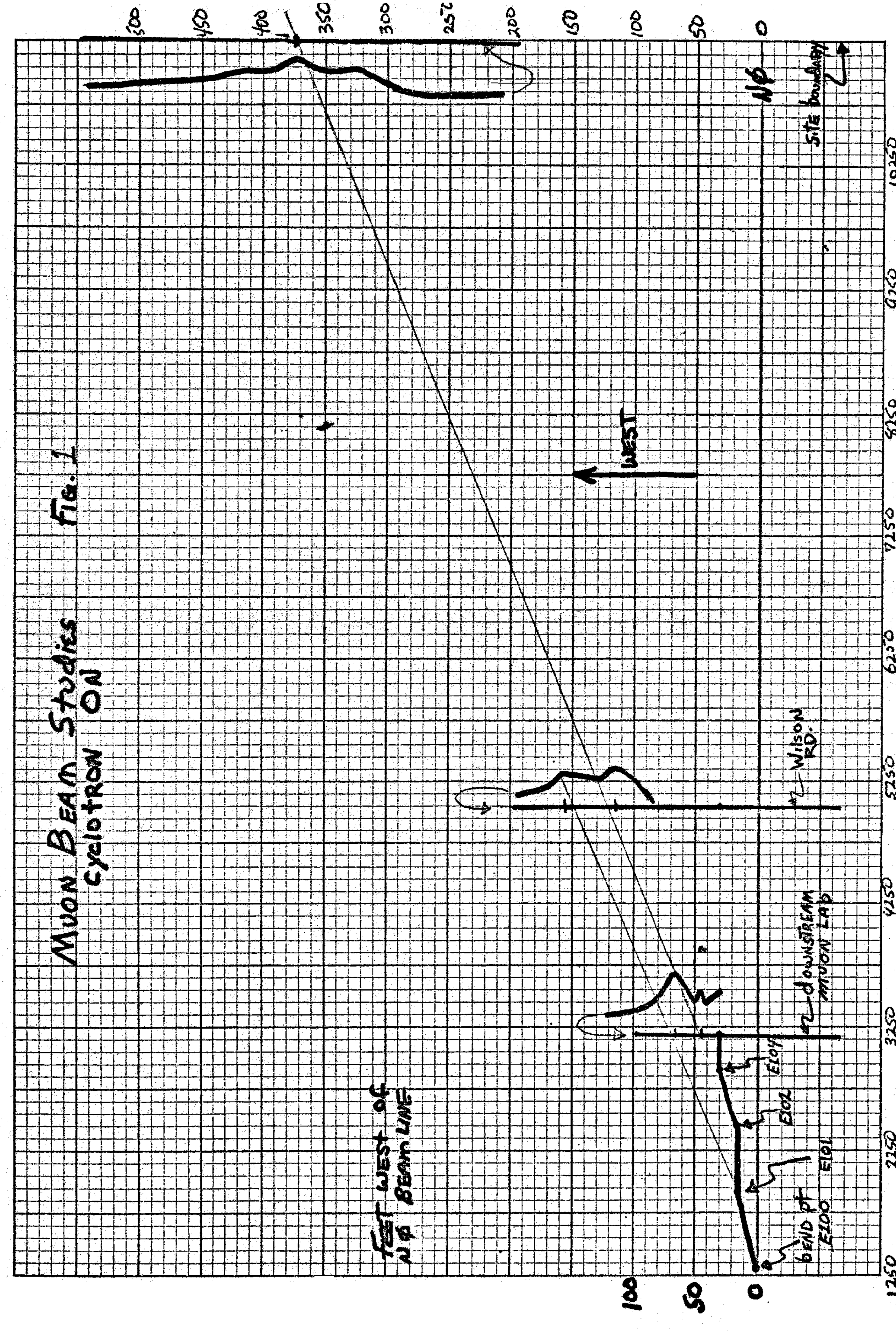
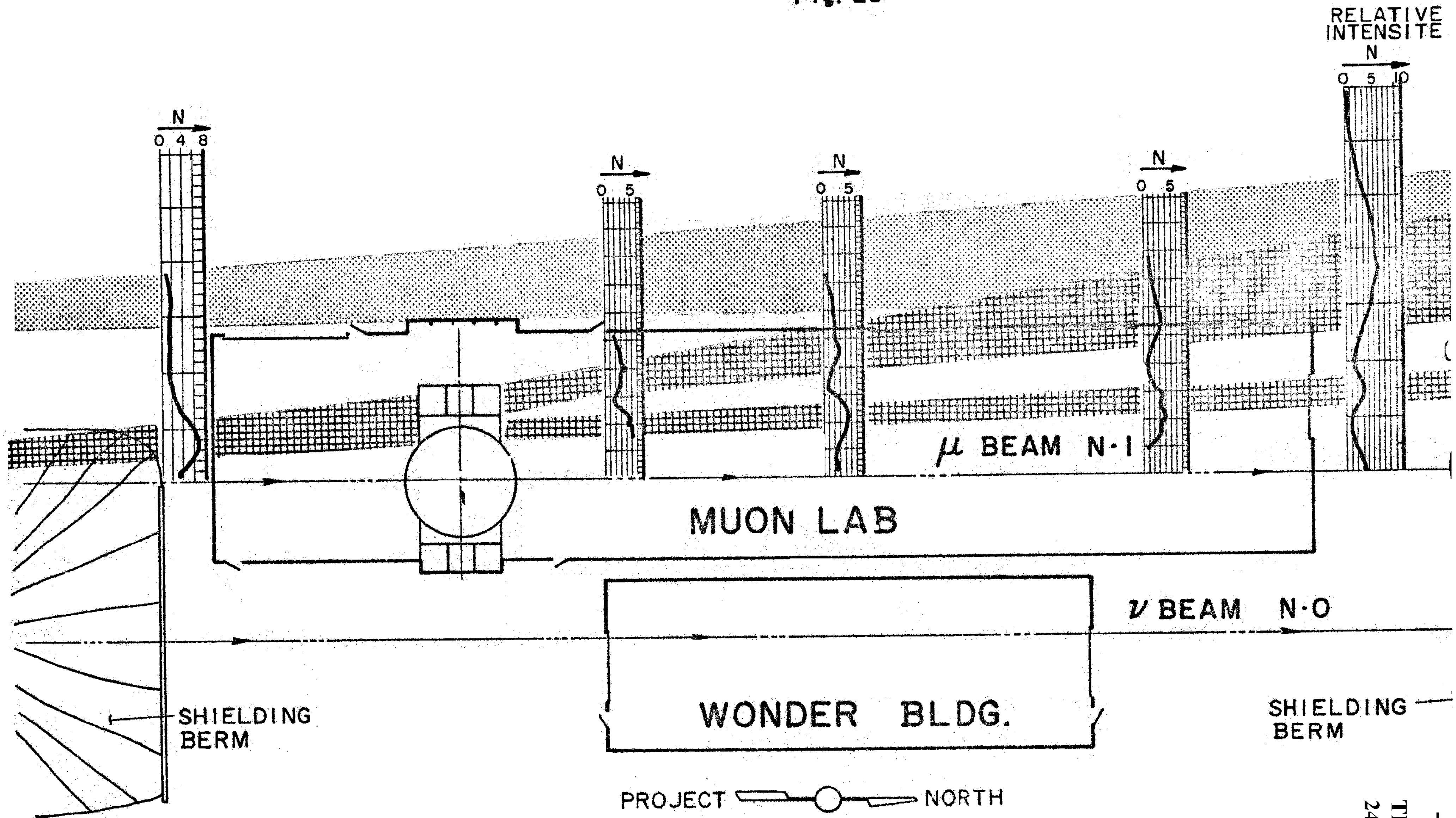

Muon Beam Studies
Cyclotron ON
Fig. 1
Feet West of Nφ Beam Line
Feet downstream of Nφ target
WEST
Nφ
Site boundary
Wilson Rd.
downstream Muon Lab
E104
E102
E101
bend of E100
1250
2250
3250
4250
5250
6250
7250
8250
9250
10250
0
50
100
150
200
250
300
350
400
450
500

MUON BEAM HALO STUDIES

CYCLOTRON MAGNET ON

Fig. 2a



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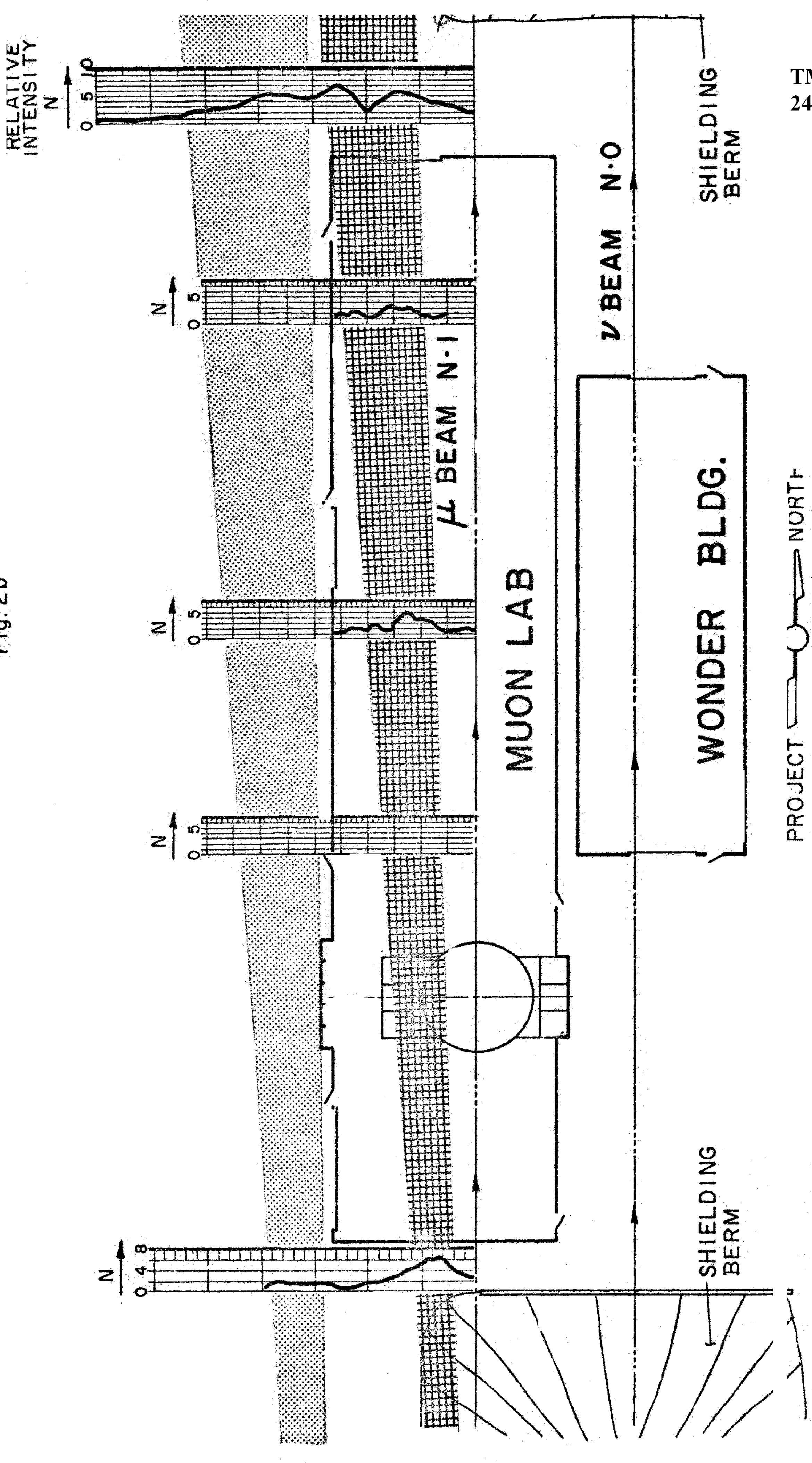
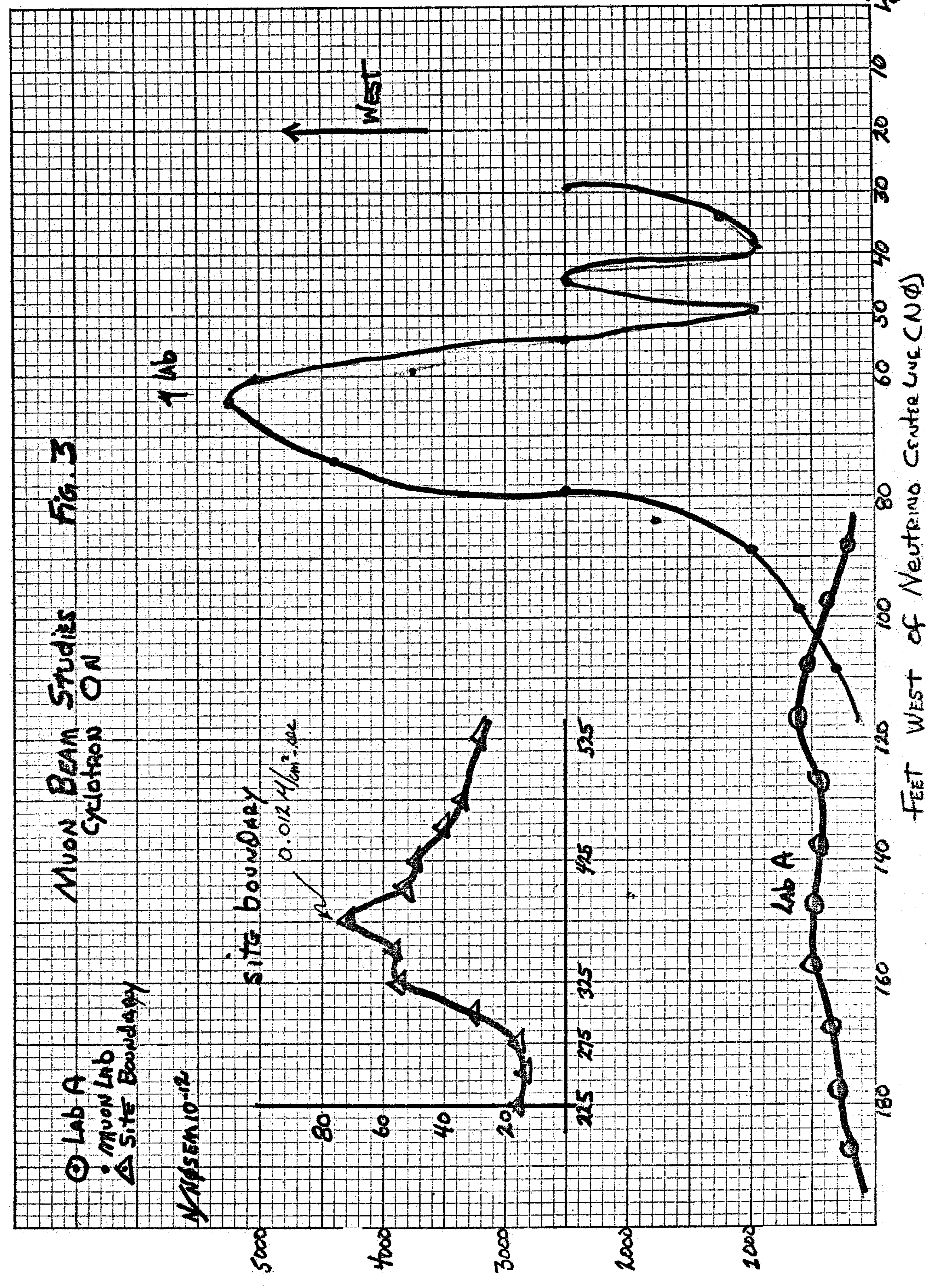
MUON BEAM HALO STUDIES

CYCLOTRON MAGNET OFF

Fig. 2b




Muon Beam Studies
Cyclotron ON
Fig. 3
Lab A
Muon Lab
Site Boundary
Site Boundary
WEST
μ lab
Lab A
Feet West of Neutrino Center Line (N∅)
5000
4000
3000
2000
1000
80
60
40
20
225
275
325
425
525
10
20
30
40
50
60
80
100
120
140
160
180